

IN THE CLAIMS:

The text of all pending claims, (including withdrawn claims) is set forth below. Cancelled and not entered claims are indicated with claim number and status only. The claims as listed below show added text with underlining and deleted text with ~~striketrough~~. The status of each claim is indicated with one of (original), (currently amended), (cancelled), (withdrawn), (new), (previously presented), or (not entered).

1. (Original) An apparatus for detecting or predicting a breakage of a tool used in a machine tool, the apparatus comprising:

cutting load detecting means for detecting a cutting load;

means for obtaining at least one of three cutting load data by said cutting load detecting means, including a cutting time, an area of a cutting load waveform during cutting, and a maximum absolute value of a slope of a drop in a cutting load during the cutting, in a machining cycle, as a load state value in a current machining cycle;

means for updating and obtaining a moving variable threshold based on the load state value calculated in a machining cycle before the current machining cycle; and

means for comparing the load state value in the current machining cycle with the moving variable threshold to determine an abnormal condition of the tool.

2. (Original) The apparatus for detecting or predicting a breakage of a tool according to claim 1, wherein the machining cycle before the current cycle is the machining cycle immediately before or a plurality of cycles before the current machining cycle.

3. (Original) The apparatus for detecting or predicting a breakage of a tool according to claim 1, wherein the moving variable threshold is obtained based on an average value of load state values of respective machining cycles and calculated in all machining cycles from a first machining cycle to a machining cycle immediately before the current machining cycle or in a plurality of machining cycles before the current machining cycle.

4. (Original) The apparatus for detecting or predicting a breakage of a tool used in a machine tool, the apparatus comprising:

cutting load detecting means for detecting a cutting load;

means for obtaining at least one of three cutting load data by said cutting load detecting

means, including a cutting time, an area of a cutting load waveform during cutting, and a maximum absolute value of a slope of a drop in a cutting load during the cutting, in a machining cycle, as a load state value in a current machining cycle;

means for updating and obtaining a moving variable threshold based on the load state value calculated in a machining cycle for a preceding workpiece at the machining position which corresponds to the machining position in the current machining cycle; and

means for comparing the load state value in the current machining cycle with the moving variable threshold to determine an abnormal condition of the tool.

5. (Original) The apparatus for detecting or predicting a breakage of a tool according to claim 4, wherein the preceding workpiece is the workpiece immediately before or a plurality of cycles before the current machining cycle.

6. (Original) The apparatus for detecting or predicting a breakage of a tool according to claim 4, wherein the moving variable threshold is obtained based on an average value of load state values in machining cycles at the corresponding machining positions, calculated for all workpieces from a workpiece machined first to a workpiece machined in an immediately preceding cycle or in a plurality of workpieces machined before.

7. (Previously Presented) The apparatus for detecting or predicting a breakage of a tool according to claim 1, wherein the moving variable threshold is obtained by multiplying the obtained load state value by a predetermined coefficient.

8. (Previously Presented) The apparatus for detecting or predicting a breakage of a tool according to claim 1, wherein the moving variable threshold is obtained by adding a predetermined value to the obtained load state value.

9. (Previously Presented) The apparatus for detecting or predicting a breakage of a tool according to claim 1, further comprising means for providing an instruction to activate an audible alarm and/or a warning light or means for providing an instruction to replace the tool or to stop operation of the machine when the means for determining an abnormal condition of the tool determines that the tool is in an abnormal condition.

10. (Previously Presented) The apparatus for detecting or predicting a breakage of a tool according to claim 1, wherein the means for determining an abnormal condition of the tool determines that the tool is in an abnormal condition when the load state value in the current machining cycle exceeds the moving variable threshold.

11. (Previously Presented) The apparatus for detecting or predicting a breakage of a tool according to claim 1, wherein the means for determining an abnormal condition of the tool determines that the tool is in an abnormal condition when the load state value in the current machining cycle becomes smaller than the moving variable threshold.

12. (Previously Presented) The apparatus for detecting or predicting a breakage of a tool according to claim 1, wherein the means for determining an abnormal condition of the tool obtains a first moving variable threshold and a second moving variable threshold smaller than the first moving variable threshold for the area of the cutting load waveform and the maximum absolute value of the slope of the drop in the cutting load and determines that the tool is in an abnormal condition when the load state value in the current machining cycle exceeds the first moving variable threshold or when the load state value in the current machining cycle becomes smaller than the second moving variable threshold.

13. (Previously Presented) The apparatus for detecting or predicting a breakage of a tool according to claim 1, wherein the cutting load detecting means detects a load of a feed shaft or a main shaft to which the cutting load is applied.

14. (Previously Presented) The apparatus for detecting or predicting a breakage of a tool according to claim 1, wherein the cutting load detecting means detects the load by an observer for estimating an applied load or by a driving current of a motor for driving a feed shaft or a motor for driving a main shaft to which the cutting load is applied.

15. (Previously Presented) The apparatus for detecting or predicting a breakage of a tool according to claim 4, wherein the moving variable threshold is obtained by multiplying the obtained load state value by a predetermined coefficient.

16. (Previously Presented) The apparatus for detecting or predicting a breakage of a tool according to claim 4, wherein the moving variable threshold is obtained by adding a predetermined value to the obtained load state value.

17. (Previously Presented) The apparatus for detecting or predicting a breakage of a tool according to claim 4, further comprising means for providing an instruction to activate an audible alarm and/or a warning light or means for providing an instruction to replace the tool or to stop operation of the machine when the means for determining an abnormal condition of the tool determines that the tool is in an abnormal condition.

18. (Previously Presented) The apparatus for detecting or predicting a breakage of a tool according to claim 4, wherein the means for determining an abnormal condition of the tool determines that the tool is in an abnormal condition when the load state value in the current machining cycle exceeds the moving variable threshold.

19. (Previously Presented) The apparatus for detecting or predicting a breakage of a tool according to claim 4, wherein the means for determining an abnormal condition of the tool determines that the tool is in an abnormal condition when the load state value in the current machining cycle becomes smaller than the moving variable threshold.

20. (Previously Presented) The apparatus for detecting or predicting a breakage of a tool according to claim 4, wherein the means for determining an abnormal condition of the tool obtains a first moving variable threshold and a second moving variable threshold smaller than the first moving variable threshold for the area of the cutting load waveform and the maximum absolute value of the slope of the drop in the cutting load and determines that the tool is in an abnormal condition when the load state value in the current machining cycle exceeds the first moving variable threshold or when the load state value in the current machining cycle becomes smaller than the second moving variable threshold.

21. (Previously Presented) The apparatus for detecting or predicting a breakage of a tool according to claim 4, wherein the cutting load detecting means detects a load of a feed shaft or a main shaft to which the cutting load is applied.

22. (Previously Presented) The apparatus for detecting or predicting a breakage of a tool according to claim 4, wherein the cutting load detecting means detects the load by an observer for estimating an applied load or by a driving current of a motor for driving a feed shaft or a motor for driving a main shaft to which the cutting load is applied.

23. (Previously Presented) A method to determine a condition of a tool used in a machine tool, comprising:

obtaining a load state value during a current machining cycle;

updating a moving variable threshold based on a prior load state value calculated in a machining cycle before the current machining cycle; and

comparing the load state value in the current machining cycle with the moving variable threshold to determine a condition of the tool.

24. (Previously Presented) The method as recited in claim 15, wherein the load state value includes at least one of a cutting time, an area of a cutting load waveform during cutting, and a maximum absolute value of a slope of a drop in a cutting load during the cutting.

25. (Previously Presented) An apparatus to determine a condition of a tool used in a machine tool, comprising:

a cutting load detector to detect a cutting load;

a monitor to obtain, via the cutting load detector, at least one of a cutting time, an area of a cutting load waveform during cutting, and a maximum absolute value of a slope of a drop in a cutting load during the cutting, in a machining cycle, as a load state value in a current machining cycle;

a threshold calculator to update a moving variable threshold based on the load state value calculated in a machining cycle before the current machining cycle; and

an analyzer to compare the load state value in the current machining cycle with the moving variable threshold to determine a condition of the tool.